

Method for conducting crash tests using a carriage  
and corresponding apparatus

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The present invention relates to a method for conducting crash tests using a carriage, in particular for simulating the collision of a motor vehicle with an obstacle, in which the deceleration forces of a real collision are simulated by accelerating a crash-test carriage in accordance with the real deceleration curve. The invention moreover relates to an apparatus for carrying out such a method.

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When a vehicle collides with a resistance, for example another vehicle, in an accident, it is decelerated in accordance with the deformability of the vehicle and the resistance. This deceleration initiates an acceleration onto the movable masses of the vehicle. In order to be able to investigate these acceleration forces, it is known to conduct real crash tests in which a vehicle is accelerated to a desired speed and collides with an obstacle. The vehicle is, however, destroyed thereby and cannot be used for further crash tests.

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To allow acceleration forces to be investigated in accidents without having to destroy a whole vehicle for this purpose, so-called crash tests using a carriage are conducted, in which a carriage is accelerated to the desired speed, for example by a pre-stressed elastic cable. The carriage then collides with a deformable obstacle at this speed. However, with this kind of test, it is difficult to recreate deceleration curves from real crash tests.

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It is therefore also known to simulate the deceleration of a real crash test by an acceleration of the test object. This means that the acceleration forces acting on the movable masses of the vehicle on collision with an obstacle are exerted directly via an acceleration of the crash-test carriage onto the test object. Real deceleration curves can thus be recreated substantially better.

In known methods, in order to conduct such tests, the carriage is accelerated by a thrust rod which is hydraulically moved out of a cylinder tube in accordance with a real deceleration curve. In order to recreate the real deceleration curve, the hydraulic pressure exerted on the thrust rod is controlled by a hydraulic valve. In view of the high required acceleration, this must have an extremely high flow rate and must be able to react very quickly. A plurality of calibration tests must be conducted for the adaptation to the real deceleration curve since such a valve cannot be regulated within the test time of a maximum of 100 milliseconds. This process is therefore relatively expensive and time-consuming.

It is the underlying object of the invention to provide a method for conducting crash tests using a carriage with which real deceleration curves can likewise be recreated very precisely, but which is less expensive and time-consuming. Furthermore, an apparatus for carrying out such a method is to be set forth.

This object is satisfied in that during the test, a force is exerted on the crash-test carriage in the direction of acceleration, which is larger than

the respective force required for acceleration in accordance with the real deceleration curve, on the one hand, and that in order to achieve the desired acceleration curve, a braking force opposite to the direction of acceleration is exerted on the crash-test carriage or on an apparatus  
5 driving it, which is so large that the resulting force accelerates the carriage in accordance with the desired acceleration curve, on the other hand.

The generation of acceleration and the adaptation of the acceleration to a desired curve can be advantageously separated from one another by the  
10 exertion of an acceleration force on the crash-test slide, on the one hand, and of a braking force, on the other hand. The adaptation is thereby possible with a relatively low effort. In particular, a regulation can be carried out. Time-consuming calibration tests are thereby made superfluous so that the method overall requires much less effort than the one described  
15 above and nevertheless allows a very exact adaptation to the desired acceleration curve.

In accordance with an embodiment of the invention, the force acting in the direction of acceleration is produced pneumatically. This is possible in a  
20 simple manner and allows, likewise in a simple manner, a repeated conducting of crash tests using a carriage.

In accordance with a further embodiment of the invention, a pressure is generated in a pressure reservoir at maximum braking force, said pressure corresponding at least to the maximum required acceleration force,  
25 and subsequently the brake is gradually opened in accordance with the acceleration curve. In this way, the adaptation of the acceleration to the

acceleration curve can be achieved solely by a controlled or regulated opening of the brake. This is in particular of advantage when carrying out a real-time regulation.

- 5 In accordance with a further embodiment of the invention, the generation of the required pressure is controlled via a pressure sensor arranged in the pressure reservoir, in particular by using a computer. In this way, the exact pressure generation is ensured in the pressure reservoir in a skilled manner.

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- In accordance with a further embodiment of the invention, the braking force is hydraulically transferred onto the brake carriage or onto an apparatus driving it. An exact control and regulation is thus possible in a particularly easy manner. As a result of the relatively low amount of hydraulic fluid required, valves with a comparatively low flow rate, in particular standard hydraulic valves, can be used, which can also be regulated in real time.

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- In accordance with a further embodiment of the invention, an emergency braking of an apparatus driving the crash-test carriage and loosely engaging at this is carried out at the end of the crash test using a carriage, with the end of the crash test using a carriage preferably being determined via the path covered, the time and/or the speed of the crash-test carriage. The exertion of an uncontrolled force on the crash-test carriage after the end of the test is thus prevented.

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An apparatus for conducting the method comprises, in accordance with the invention, a pressure chamber whose volume is restricted by a piston which acts on the crash-test carriage via a thrust rod, by a compressor for generating the required pressure in the pressure chamber and by a brak-  
5 ing device acting on the crash-test carriage or on the thrust rod. Crash tests using a carriage in accordance with the invention can thus be conducted in an advantageous manner with pneumatic acceleration.

In accordance with a further embodiment of the invention, the pressure  
10 chamber has a safety valve to restrict the maximum pressure. Damage to the system due to excess pressure is thereby avoided.

In accordance with a further embodiment of the invention, a pressure sensor is present in the pressure chamber whose output signal is trans-  
15 mitted to a control unit to control the pressure generation. The achieving of the required pressure in the pressure chamber is thus ensured.

In accordance with a further embodiment of the invention, a pressure switch is provided in the pressure chamber whose response pressure lies  
20 somewhat below the safety valve pressure and which is switched off by the compressor. The compressor is thus automatically switched off before the maximum permitted pressure is reached and the occurrence of excess pressure is avoided.

25 In accordance with a further embodiment of the invention, the brake device acting on the crash-test carriage or on the thrust rod can be hydraulically actuated. This is advantageous for construction and allows a

control, and in particular a regulation, of the braking force. A standard hydraulic valve is preferably provided for this purpose.

5 In accordance with a further embodiment of the invention, the braking force can be regulated in dependence on the acceleration of the crash-test carriage. An acceleration sensor is provided for this which measures the acceleration of the crash-test carriage. Another possibility consists of regulating the braking force in dependence on the desired pressure of the hydraulic brake.

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In accordance with a further embodiment of the invention, the crash-test carriage can be displaced by means of a thrust rod engaging loosely at the carriage, with the brake device preferably acting on the thrust rod. This is advantageous for construction and also allows the crash-test carriage to roll out at the end of the test.

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In accordance with a further embodiment of the invention, a plurality of units are provided in order to generate the acceleration force. The force required to accelerate the crash-test carriage can thereby be generated more simply.

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An embodiment of the invention is illustrated in the drawing and will be described in the following. There is shown, in a schematic illustration,

25 Figure 1 a side view of a crash-test carriage system of the invention.

An air pressure required for conducting a crash test using a carriage is generated in a compressed air tube 2 by a compressor 1, with it being ensured by a safety valve 3 that a maximum pressure is not exceeded in the compressed air tube 2.

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A pressure sensor 4 is connected to the compressed air tube 2 and this measures the actual pressure in the compressed air tube 2 and forwards it to a control computer not shown here. When the desired pressure is reached, the control computer initiates the switching off of the compressor

10 1. In addition, a pressure switch 5 can be connected to the compressed air tube 2 whose response pressure lies somewhat below the response pressure of the safety valve 3. When the pressure switch 5 responds, the compressor 1 is switched off. Finally, a rotary valve 6 is connected to the compressed air tube 2 and the pressure in the compressed air tube 2 can  
15 be lowered to ambient pressure by this.

A thrust rod 7 is inserted into the compressed air tube 2 and has a piston 8 at its inner end which is sealingly guided in the compressed air tube 2 and thereby limits the compressed air volume V in the compressed air  
20 tube 2. The other end of the thrust rod 7 engages at a crash-test carriage 9 which can be displaced on rails 10 in the direction of the longitudinal axis I of the thrust rod 7. The starting position of the crash-test carriage 9 is determined by a stop 11. Furthermore, an acceleration sensor 12 is provided at the crash-test carriage 9 and the acceleration of the crash-test  
25 carriage 9 in the direction of the arrow 2 can be measured by this and transmitted to a control computer not shown here.

A hydraulically actuatable brake device 13 engages at the thrust rod 7. The flow of hydraulic fluid 15 from a hydraulic unit 15 to the brake device 13 is regulated via a servo valve 14. Moreover, a pressure sensor 16 is present at the brake device 13 which measures the brake pressure and  
5 transmits it to the control device not shown here.

To conduct a crash test using a carriage, the servo valve 14 is first fully opened so that the brake device 13 is closed and the thrust rod 7 is held at its starting position in which the crash-test carriage 9 contacts the stop  
10 11. Now, the required pressure is built up in the compressed air tube 2 via the compressor 1. When the test starts, the servo valve 14 begins to regulate the braking force on the thrust rod 7 in accordance with a desired acceleration curve. The actual acceleration of the crash-test carriage 9 is measured directly via the acceleration sensor 12 and used in the control  
15 computer to regulate the braking force. Alternatively, the braking force can be measured via the brake pressure sensor 16 and the braking force be regulated in dependence on the brake pressure.

As soon as at least one of the termination criteria – path covered, time  
20 and/or speed of the crash-test carriage 9 – has been satisfied, the servo valve 14 opens fully again so that an emergency braking of the thrust rod 7 is initiated. The crash-test carriage 9 thereby lifts of the thrust rod 7 and rolls out on the rails 10. For the next text, the carriage 9 and the thrust rod 7 are pushed back into the starting position in which the car-  
25 riage 9 contacts the stop 11.

The conducting of the crash test using a carriage can be carried out in a particularly suitable manner with this arrangement, with a very precise adaptation to a real acceleration curve being achieved by the separation of the generation of the acceleration force and the adaptation of the acceleration to a desired acceleration curve via the brake device 13. The pneumatic generation of the acceleration force and the hydraulic brake device are in this respect advantageous in particular for a repeated conducting of the crash test using a carriage.

Reference numeral list

	1	compressor
	2	compressed air tube
5	3	safety valve
	4	pressure sensor
	5	pressure switch
	6	rotary valve
	7	thrust rod
10	8	piston
	9	crash-test carriage
	10	rails
	11	stop
	12	acceleration sensor
15	13	brake device
	14	servo valve
	15	hydraulic unit
	16	brake pressure sensor
	I	longitudinal axis of 7
20	II	direction of acceleration
	V	compressed air volume